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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING JANUARY, 1929

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and their exposures at the several observing stations the following references may be consulted:

Washington, D. C., Mo. Wea. Rev., 53: 318, July, 1925.

Madison, Wis., Mo. Wea. Rev., 44: 2, Jan., 1916; 44: 180, Apr., 1916.

Lincoln, Nebr., Mo. Wea., Rev., 44: 2, Jan. 1916; 44: 179, Apr., 1916.

Chicago, Ill., Mo. Wea. Rev., 51: 533, Oct. 1923.

New York, N. Y., Mo. Wea. Rev., 53: 29, Jan., 1925.

Twin falls, Idaho, Mo. Wea. Rev., 55: 29, Jan., 1927.

An account of the method of obtaining and reducing the radiation measurements will be found in the following references:

Marvin pyrheliometer, Mo. Wea. Rev., 47: 769, Nov., 1919.

Callendar pyrheliometer, Mo. Wea. Rev., 42: 474, Aug., 1914.

W. B. thermoelectric pyrheliometer, Mo. Wea. Rev., 51: 239, May, 1923.

Moll pyrheliometer, Mo. Wea. Rev., 54: 381, Sept., 1926.

On October 6, 1928, a Moll thermopile, recording on an Engelhard microammeter, was installed at Fresno, Calif. The pyrheliometer is exposed at the west corner of the roof of the building in which the Weather Bureau office is located, on a small stand slightly higher than the roof parapet. The register is on a table in the Weather Bureau office room, which is on the top floor of the building.

The coordinates of the Weather Bureau office are as follows: Latitude, 36° 43' north; longitude, 119° 49' west of Greenwich; altitude of pyrheliometer, 350 feet above sea level, 85 feet above ground.

The San Joaquin Valley of California, in which Fresno is located, had an exceptionally dry summer in 1928, practically no rain falling in the interval April to October. In consequence the soil was very dry and enough was taken up by the wind to fill the air with dust.

The effect of the dust is seen in the atmospheric transmission of radiation as derived from solar radiation measurements made by me with a Smithsonian Silver Disk pyrheliometer, and summarized in Table 3. In the same table is included a summary of measurements made by the same instrument on March 14, 1920. Note that the atmospheric depletion in October was in excess of that in March by about 10 per cent in the early morning, 7 per cent at noon, and 1 to 2 per cent in the afternoon.

Table 1 shows that solar radiation intensities during January averaged close to normal values for the month at Washington, D. C., and Madison, Wis., and slightly above the normal at Lincoln, Nebr.

Table 2 shows that the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky was below the January normal at the five stations for which normals have been determined, the deficiency being marked at Lincoln.

Skylight polarization measurements made at Washington on two days give a mean of 58 per cent, with a maximum of 59 per cent on the 11th. These are slightly below

the corresponding average values for Washington in January. At Madison no measurements were obtained during the month, as the ground was covered with snow.

TABLE 1.—Solar radiation intensities during January, 1929

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.												
Date	Sun's zenith distance										Local mean solar time	
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°		Noon
	75th mer. time	Air mass										
		A. M.					P. M.					
		e.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0		5.0
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.	
Jan. 2	2.74				1.45						1.60	
Jan. 3	1.60		0.80		1.19						1.78	
Jan. 4	2.87	0.57	0.68	0.93	1.00						2.87	
Jan. 7	1.88	0.78	0.90	1.09				1.11	0.89	0.73	1.78	
Jan. 8	0.86			1.20	1.39						0.74	
Jan. 12	1.37	0.76	0.92	1.13	1.32			1.15	1.01	0.90	1.37	
Jan. 19	9.45				1.27			1.01	0.88	0.80	5.79	
Jan. 23	4.75		0.92	1.12	1.28		1.37	1.17	1.03	0.98	2.49	
Jan. 26	2.06	0.78	0.88	1.05	1.25		1.27	1.05	0.87	0.78	2.16	
Jan. 29	1.32	0.80	0.90	1.05	1.19			1.03	0.77	0.64	1.52	
Jan. 30	1.45	0.45	0.58	0.77	1.11		1.04	0.70			1.19	
Means		0.69	0.82	1.04	1.24		1.23	1.03	0.91	0.80		
Departures		-0.04	-0.02	+0.03	+0.01		±0.00	±0.00	+0.03	+0.01		

Madison, Wis.										
Jan. 3	2.16			1.12						2.06
Jan. 7	0.38	1.11	1.22	1.35				1.34		0.56
Jan. 11	2.16							1.29		1.52
Jan. 12	1.02							1.21		1.68
Jan. 15	0.38	1.04	1.13							0.64
Jan. 21	1.24			1.09						2.06
Jan. 23	0.53	0.98	1.08	1.21						0.71
Jan. 25	1.24							1.21		0.79
Jan. 28	0.46	0.91	1.04	1.23	1.38			1.22		0.91
Jan. 29	1.12							1.03		1.24
Jan. 31	0.79		1.02	1.22	1.44			1.25		0.74
Means		1.01	1.10	1.20	(1.41)			1.22		
Departures		+0.05	+0.02	-0.03	+0.05			+0.01		

Lincoln, Nebr.										
Jan. 3	2.74							0.88	0.77	2.36
Jan. 8	1.96		1.00	1.17				1.12	1.05	3.45
Jan. 11	0.96	1.19	1.25	1.35				1.31	1.14	0.97
Jan. 25	0.43		1.26	1.38				1.15	1.06	0.58
Jan. 31	0.66		1.15	1.23	1.40		1.41	1.21	1.03	0.86
Means		(1.19)	1.16	1.28	(1.40)		(1.41)	1.20	1.03	0.88
Departures		+0.25	+0.11	+0.09	+0.02		-0.01	+0.03	-0.02	-0.04

1 Extrapolated.

TABLE 2.—Total solar radiation (direct + diffuse) received on a horizontal surface

[Gram-calories per square centimeter]

Week begin- ning	Average daily radiation						Average daily departure from normal					
	Washing- ton	Madison	Lincoln	Chicago	New York	Twin Falls	Fresno	Washing- ton	Madison	Lincoln	Chicago	New York
Jan. 1929	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Jan. 1.....	148	139	168	86	83	189	117	-4	+2	-16	+8	-24
Jan. 8.....	180	133	153	68	112	248	118	+23	-15	-39	-12	+6
Jan. 15.....	146	143	159	86	92	189	277	-13	-18	-39	+3	-23
Jan. 23.....	144	172	168	95	156	180	272	-37	-15	-50	-11	+20
Deficiency since first of year on January 28.....								-217	-322	-1,008	-84	-147

TABLE 3.—Solar radiation intensities and atmospheric transmission coefficients at Fresno, Calif.

Date	Sun's zenith distance								
	0°	48° 3'	60° 0'	66° 5'	70° 7'	73° 6'	75° 7'	77° 4'	78° 7'
	Air mass								
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Solar radiation (Gram-calories per minute per square centimeter of normal surface)									
1928—A. M.									
Oct. 6	1.36								
Oct. 7	1.39	1.22	1.10	0.94	0.81				
Oct. 8	1.42	1.25	1.11	1.04	0.92				
Oct. 10				1.05					
Means	1.39	1.24	1.10	1.01	0.86				
1920									
Mar. 14	1.52	1.42	1.34	1.26	1.18	1.11	1.05	0.98	0.91
1928—P. M.									
Oct. 6		1.26	1.16	1.07	0.99	0.92	0.85		0.72
Oct. 7		1.28	1.17	1.10	1.03				
Oct. 8		1.29	1.20	1.13	1.01				
Means		1.28	1.18	1.10	1.01	0.92	0.85		0.72
1920									
Mar. 14		1.42	1.33	1.24	1.15	1.07	1.00	0.93	0.87
Atmospheric transmission									
A. M.—October	1.01			0.86					
	1.24	0.815		1.10	0.782				
March	1.26			1.18					
	1.42	0.887		1.34	0.881				
P. M.—October	1.10			1.01		0.72			
	1.28	0.859		1.18	0.856	0.85	0.847		
March	1.24			1.15		0.87			
	1.42	0.873		1.33	0.865	1.00	0.870		

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column.]

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longi- tude	Lati- tude	Spot	Group	
1929							
Jan. 1 (Mount Wilson)---	<i>h. m.</i> 14 5	° -31.0 -7.0 0.0 +3.0 +23.0 +40.0 +60.0	° 237.7 261.7 268.7 271.7 291.7 308.7 323.7	° -11.0 +15.0 -20.0 +10.0 +8.0 +20.0 +5.0	----- 4 ----- ----- ----- ----- ----- -----	28 ----- 35 19 253 43 13	----- ----- ----- ----- ----- ----- 395
Jan. 2 (Naval Observa- tory).	11 40	-81.0 -56.5 -18.0 +12.0 +35.0 +50.5	175.7 200.2 238.7 268.7 291.7 307.2	+12.0 +11.5 -9.5 -19.0 +8.5 +21.5	201 9 ----- ----- ----- -----	----- ----- 46 77 340 62	----- ----- ----- ----- 735 -----
Jan. 3 (Naval Observa- tory).	11 35	-67.0 -5.5 +25.5 +33.5 +49.5 +63.5	176.6 238.1 269.1 277.1 293.1 307.1	+12.5 -8.5 -18.5 +10.0 +8.5 +21.5	----- 15 ----- 22 ----- -----	247 ----- 46 ----- 370 90	----- ----- ----- ----- 790 -----
Jan. 4 (Naval Observa- tory).	11 39	-53.5 -1.0 +7.5 +40.0 +47.0 +66.0 +78.5	176.9 229.4 237.9 270.4 277.4 296.4 308.9	+12.5 +10.5 -9.0 -17.0 +9.0 +9.0 +22.5	----- ----- ----- 28 ----- 185 31	185 12 22 ----- 77 ----- -----	----- ----- ----- ----- ----- ----- 540
Jan. 5 (Mount Wilson)---	16 00	-60.0 -37.0 -16.0 +63.0 +73.0	154.8 177.8 198.8 277.8 287.8	-14.0 +12.0 -13.0 +9.0 +7.0	----- ----- ----- ----- -----	7 212 7 37 84	----- ----- ----- ----- 347
Jan. 6 (Naval Observa- tory).	11 55	-51.0 -39.0 -27.5 +12.0 +28.0 +74.0	152.9 164.9 176.4 215.9 231.9 277.9	-11.5 +16.0 +11.5 -0.5 +9.0 +8.5	----- 9 154 ----- 15 -----	----- ----- ----- 46 ----- 247	----- ----- ----- ----- ----- 533

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longi- tude	Lati- tude	Spot	Group	
1929—Continued							
Jan. 7 (Naval Observa- tory).	<i>h. m.</i> 11 52	° -36.0 -27.5 -14.5 +4.5 +25.5 +38.5	° 154.8 163.3 176.3 195.3 216.3 229.3	° -11.5 +18.0 +11.5 +11.5 -1.0 +10.0		93 77 139 46 108 108	571
Jan. 8 (Naval Observa- tory).	11 50	-81.5 -22.5 -14.0 -1.5 +17.5 +40.0 +53.5	96.1 155.1 163.6 176.1 195.1 217.6 231.1	+18.0 -11.5 +18.0 +12.0 +12.5 -1.0 +9.0	123	139 62 123 77 62 108	694
Jan. 9 (Naval Observa- tory).	10 56	-67.5 -9.5 +11.5 +30.5 +43.0 +52.5 +68.0	97.5 155.5 176.5 195.5 208.0 217.5 233.0	+18.0 -11.5 +11.5 +12.5 -12.0 -1.0 +8.5	123	62 108 62 31 77 108	571
Jan. 10 (Naval Observa- tory).	11 46	-56.0 -53.5 +3.0 +25.0 +42.0	95.3 97.8 154.3 176.3 193.3	-15.0 +18.0 -12.0 +12.0 +13.0		6 123 77 77 15	298
Jan. 11 (Naval Observa- tory).	12 27	-77.0 -39.5 -37.0 +17.5 +38.0	60.8 98.3 100.8 155.3 175.8	+7.5 +19.0 -15.0 -12.0 +12.0		201 77 15 62 46	401
Jan. 12 (Naval Observa- tory).	11 46	-63.0 -26.5 -24.5 -10.0 +21.5 +30.0 +51.5	62.0 98.5 100.5 115.0 146.5 155.0 176.5	+8.0 +19.5 -14.5 -7.5 -20.0 -12.0 +12.0		370 77 31 93 31 62 46	710
Jan. 13 (Naval Observa- tory).	11 41	-49.5 -13.0 -10.5 +4.5 +32.5 +43.0 +64.0	62.4 98.9 101.4 116.4 144.4 154.9 175.9	+7.5 +20.0 -14.5 -9.0 +5.0 -13.0 +12.0		509 123 31 108 28 9 6	814
Jan. 14 (Naval Observa- tory).	11 54	-35.0 0.0 +4.5 +16.5 +47.0	63.6 98.6 103.1 115.1 145.6	+6.5 +18.5 -15.0 -11.0 +3.5		494 62 31 216 46	849
Jan. 15 (Harvard)-----	14 2	-21.0 +15.0 +26.5 +32.5	63.0 99.0 110.5 116.5	+7.0 +20.0 -22.5 -10.0		857 164 181 376	1,578
Jan. 16 (Naval Observa- tory).	11 12	-72.0 -35.0 -10.0 +25.5 +36.5 +43.0	0.6 37.6 62.6 98.1 109.1 115.6	-11.0 +6.0 +7.5 +18.5 -22.5 -9.5		355 15 910 77 93 247	1,697
Jan. 18 (Naval Observa- tory).	14 51	-78.5 -40.0 +19.5 +54.0 +63.5 +69.5	325.8 4.3 63.8 98.3 107.8 113.8	+5.5 -10.5 +8.0 +20.0 -22.0 -9.5	15	401 679 31 31	1,188
Jan. 19 (Naval Observa- tory).	11 54	-67.0 -27.5 +31.5	325.8 5.3 64.3	+6.0 -10.0 +7.5		46 602 602	1,250
Jan. 20 (Naval Observa- tory).	11 41	-76.5 -55.0 -14.0 +45.5	303.2 324.7 5.7 65.2	+4.0 +5.5 -10.5 +7.5	77	170 432 463	1,142
Jan. 21 (Naval Observa- tory).	11 49	-68.5 -42.5 0.0 +58.0	298.0 324.0 6.5 64.5	+6.0 +5.5 -11.0 +7.5		355 201 370 370	1,296
Jan. 22 (Harvard)-----	11 42	-53.5 -28.5 +13.0 +73.0	300.0 325.0 6.5 66.5	+7.0 +8.0 -8.5 +8.5		542 329 450 423	1,744
Jan. 23 (Naval Observa- tory).	11 59	-43.0 -15.0 +27.5	297.0 325.0 7.5	+7.5 +6.5 -10.0		309 139 231	679
Jan. 24 (Harvard)-----	12 16	-28.5 -2.0 +42.0	298.5 325.0 9.0	+7.5 +6.5 -11.0		495 272 369	1,136
Jan. 25 (Mount Wilson)...	18 35	-12.0 -8.0 +15.0 +57.0	298.1 302.1 325.1 7.1	+10.0 +5.0 +5.0 -11.0		146 117 50 205	518